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MORPHOLOGY AND DISTRIBUTION OF SENSILLA ON THE ANTENNA OF *OMOGLYMMIUS AMERICANUS* (LAPORTE 1836) (COLEOPTERA: RHYSODIDAE)

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Abstract.—Morphology, distribution, and number of sensilla on the female and male antennae of *Omoglymmius americanus* (Laporte 1836) are described using scanning electron and light microscopy. Both sexes have the same types of sensilla, 3 types of sensilla trichodea (ST), 3 types of sensilla basiconica (SB), 1 type each of sensillum coeloconicum (SCO), and sensillum ampullaceum (SA). ST_1 and ST_2 are the only non-porous types, whereas all other types are porous as indicated by their staining with silver nitrate and crystal violet. ST_1 is found on the scape, pedicel and all flagellomeres; ST_2 on all flagellomeres; ST_3 on flagellomeres 3–9; SB_1 and SB_2 on flagellomeres 3–9; SB_3 on flagellomeres 7–9; SCO and SA on the apical flagellomere. The males have significantly more SB_3 and SCO. Patches of microtrichia and pores are situated on the scape, pedicel and flagellomeres 1 and 2.

Key Words: cuticular sensory receptors, caraboid beetle

Species of the family Rhysodidae are considered to be caraboids that have a modified head and mouthparts, and some taxonomists have placed these beetles in the Carabidae (Bell 1970, 1998; Bell and Bell 1982). These beetles feed on slime molds (Bell 1994) and have modified mouthparts which are used for wedge-pushing between layers of wood. There are a number of systematic and ecological studies on this group of beetles, but studies are lacking on how these beetles perceive stimuli such as chemical cues for host and/or mate location. To date, there are no studies on the sensilla that perceive various mechanical and chemical stimuli which are encountered by these beetles. This investigation presents data on the morphology, number and distribution of sensilla on the antennal flagellum of *Omoglymmius americanus* (Laporte 1836) (Coleoptera: Rhysodidae).

Methods

For scanning electron microscopy (SEM), specimens of *Omoglymmius americanus* were placed in half strength Karnovsky's fixative in 0.1/M phosphate buffer, pH 7.2 at 4°C overnight and then post-fixed in 2% OsO_4 in the same buffer for 4h. The specimens were dehydrated in a graded series of ethanol, critical point dried and then mounted on aluminum stubs with carbon sticky tabs (Baker and Monroe 1995). After coating with gold-palladium, the material was examined with a Cambridge (LEO) 360 SEM at 15kV.

To determine the porosity of the different types of sensilla, the crystal violet procedure of Slifer (1960) and silver nitrate method of Schafer and Sanchez (1976) were used on three female and three male specimens. These same specimens were also used to make counts and measurements of the sensilla. The measurements are given as a mean plus the range. Student t-test was used to compare the mean number of sensillar types between females and males.

Results

Antenna

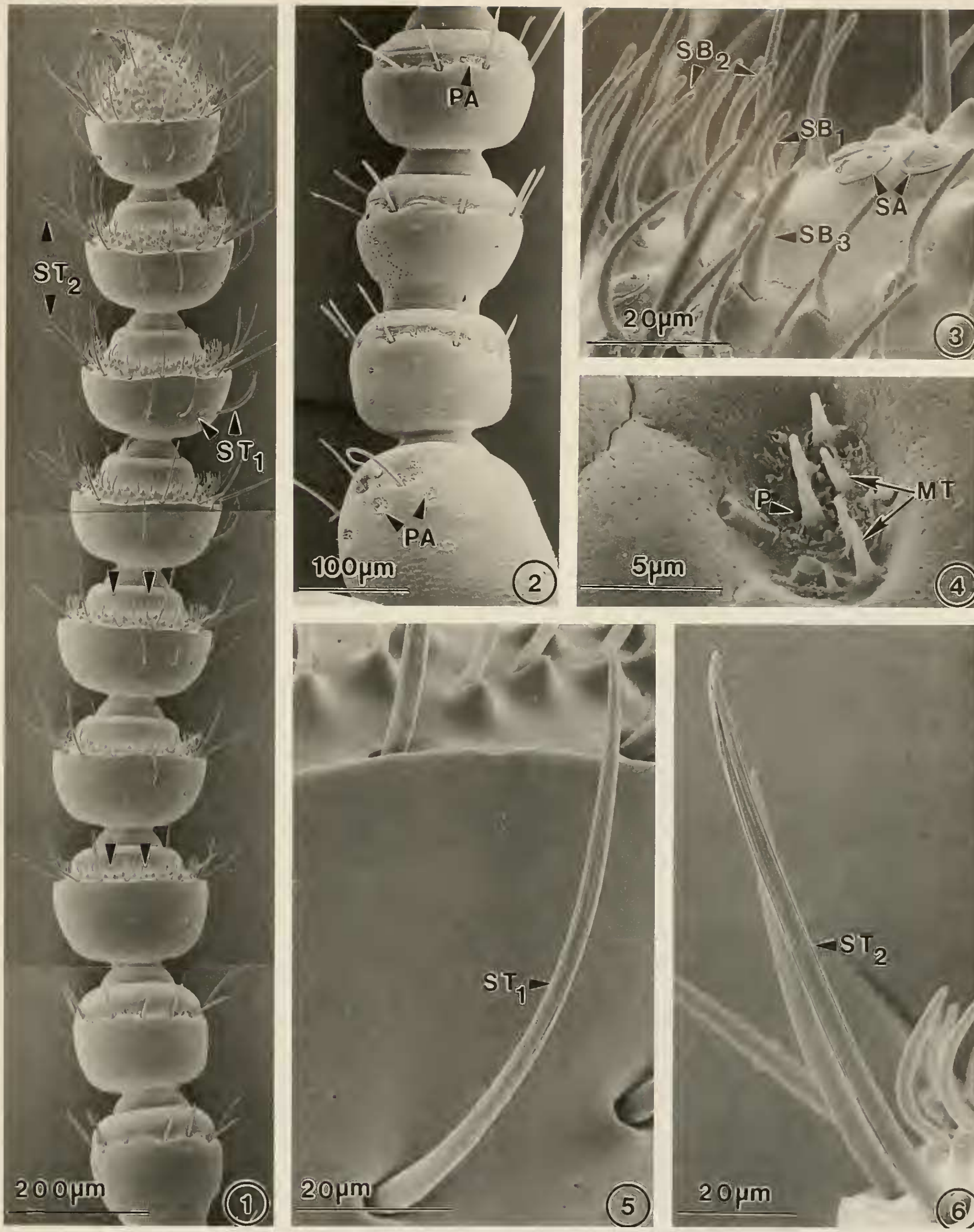
The antenna consists of a scape, a pedicel and nine flagellomeres that make-up the flagellum (Fig. 1). The scape is 260 μm (256–263) long and 255 μm (252–258) wide and square whereas the pedicel is 148 μm (145–151) long and 200 μm (196–206) wide (Fig. 2) and rectangular in shape. The nine flagellomeres are moniliform with a tapered distal end which encloses the ball-like base of the succeeding flagellomere and are globular and 200 μm (196–204) long and 254 μm (252–257) wide (Fig. 1).

On the scape, pedicel, and the first two flagellomeres there are patches of microtrichia (PA, Fig. 2). The patches are scattered over the surface of the scape and pedicel but are found only in association with the distal sensilla trichodea that encircle the flagellomeres (A_1 and A_2) (Fig. 2). The microtrichia are 3.0 to 4.5 μm long and a patch may contain from about 50 to 200 microtrichia (MT, Fig. 4). Pores are also situated in these patches of microtrichia (P, Fig. 4).

The distal half of the last flagellomere is conical and its surface is covered with sensilla whereas flagellomeres 3 to 8 have a distinct band of sensilla in a recessed area on the distal end of each flagellomere (Fig. 1, arrowheads pointing out distal bands of sensilla). The pedicel, scape, and flagellomers one and two do not have a distinct band of sensilla, but the few sensilla on their surface are all concentrated at the distal end of the flagellomere (Fig. 2). Based upon their morphology and porosity, 3 types of sensilla trichodea (ST), 1 type of sensillum ampullaceum (SA), 1 type of sensillum coelconicum (SC), and 3 types of sensilla basiconica (SB) are present on the antennae of the female and male. Their distribution and numbers are given in Table 1 and Figs. 12, 13. No differences in types, number and dimensions occur between the female and male except the male have significantly more sensillum basiconicum III and sensillum coeloconicum. The distribution patterns of each type of sensillum on both sexes also are very similar (Figs. 12, 13).

Sensillum trichodeum (ST).—The first type of sensillum trichodeum (ST_1) is located on the scape, pedicel and flagellomeres 3 to 9 in the center of each flagellomere. They form a ring of sensilla around each flagellomere and project outwards from the surface of the flagellomere (Fig. 1). ST_1 is distinctly curved with a pointed apex, and longitudinal ridges occur on the surface of the sensillum (Fig. 5). This sensillum is 80 μm (76–85) long and 4.4 μm (4.3–4.6) wide at the base. ST_2 is located on all flagellomeres and occurs in a ring around the apical portion of each flagellomere (Figs. 1, 2). It is straight, pointed and with well-defined longitudinal ridges on the cuticular shaft of the sensillum (Fig. 6). This sensillum is 87 μm (85–91) long and 5.1 μm (4.9–5.3) wide at the base. ST_1 and ST_2 increase in number from the proximal end to the distal end of the antenna (Fig. 12) and they did not stain with crystal violet or silver nitrate. The third type of sensillum trichodeum (ST III) is found in the distal sensory band on the flagellomeres (Fig. 7). There are 4–6 ST_3 that encircle a flagellomere which is 44 μm (42–47) long and 3.9 μm (3.7–4.1) wide at the base. The cuticular shaft is straight, with slight longitudinal fluting, and a blunt tip with an apical pore. This sensillum stained with crystal violet and silver nitrate and also increases in number from flagellomere 3 to 9 (Fig. 12).

Sensillum basiconicum (SB).—Type I sensillum basiconicum (SB_1) is 23 μm (19–25) long and 2.7 μm (2.6–2.9) wide at the base and distinctly curved (Figs. 3, 8). It has a blunt tip and smooth surface. Type II (SB_2) is similar morphologically to SB_1 but is 35 μm long (33–38) and 2.8 μm (2.6–



Figs. 1–6. Antennomeres and sensilla of *Omoglymmuis americanus.* 1, Distribution pattern of sensilla on the flagellomeres 1–9. 2, Sensilla and patches of microtrichia on the scape, pedicel and flagellomeres 1–2. 3, Three types of sensilla basiconica and sensillum ampullaceum on the terminal flagellomere. 4, Microtrichia and pores on the scape. 5, Long, slender, curved, pointed and grooved sensillum trichodeum, type one. 6, Long, straight and deeply grooved sensillum trichodeum, type two. Abbreviations: MT = microtrichia; P = pores; PA = patches of microtrichia; SA = sensillum ampullaceum; SB = sensillum basiconicum; ST = senillum trichodeum; double arrow heads in Fig. 1 showing the apical concentration of sensilla on each flagellomere.

Table 1. Number (mean ± SE) of sensilla on the antennal flagellum.

Type	Female	Male
ST_1	54.37 ± 2.91	56.10 ± 2.83
ST_2	139.89 ± 4.01	142.74 ± 3.83
ST_3	43.92 ± 2.96	45.18 ± 3.21
SB_1	178.84 ± 2.95	181.25 ± 3.14
SB_2	196.85 ± 4.12	201.15 ± 4.22
SB_3	28.94 ± 2.02	38.78 ± 1.97*
SCO	2.75 ± 0.15	5.50 ± 0.20*
SA	5.50 ± 0.10	5.66 ± 0.20

* Indicates significant difference on mean number of sensilla on the antennal flagellum between female and male ($p < 0.05$).

2.9) wide at the base (Fig. 9). SB_1 and SB_2 form a distinct distal band (which is called the pubescent, subapical band in the taxonomic literature) on flagellomeres 3 to 9. The number of SB_1 and SB_2 sensilla increases from flagellomere 3 to flagellomere 9 (Fig. 13). A third type of sensillum basiconicum (SB_3) is on flagellomeres 7 to 9 and is 19 μm (17–21) long and 3.0 μm (2.8–3.3) wide at the base (Fig. 10). This sensillum is not distinctly curved and has a stout appearance. All 3 types of sensilla basiconica stained intensely with crystal violet and silver nitrate which indicates their porosity.

Sensillum coeloconicum (SCO).—It is located on the last flagellomere of the female and male antennae. Females have 2–3, whereas the males have 5–6. The pit in which the sensillum is situated measures 1.9 μm (1.7–2.2) in diameter, and the cuticular peg portion is 1.7 μm (1.5–2.0) long and 0.9 μm (0.8–1.1) wide at the base (Fig. 11). The apical portion of the sensillum is distinctly pointed, and the cuticular peg also stained with the crystal violet and silver nitrate indicating its porosity.

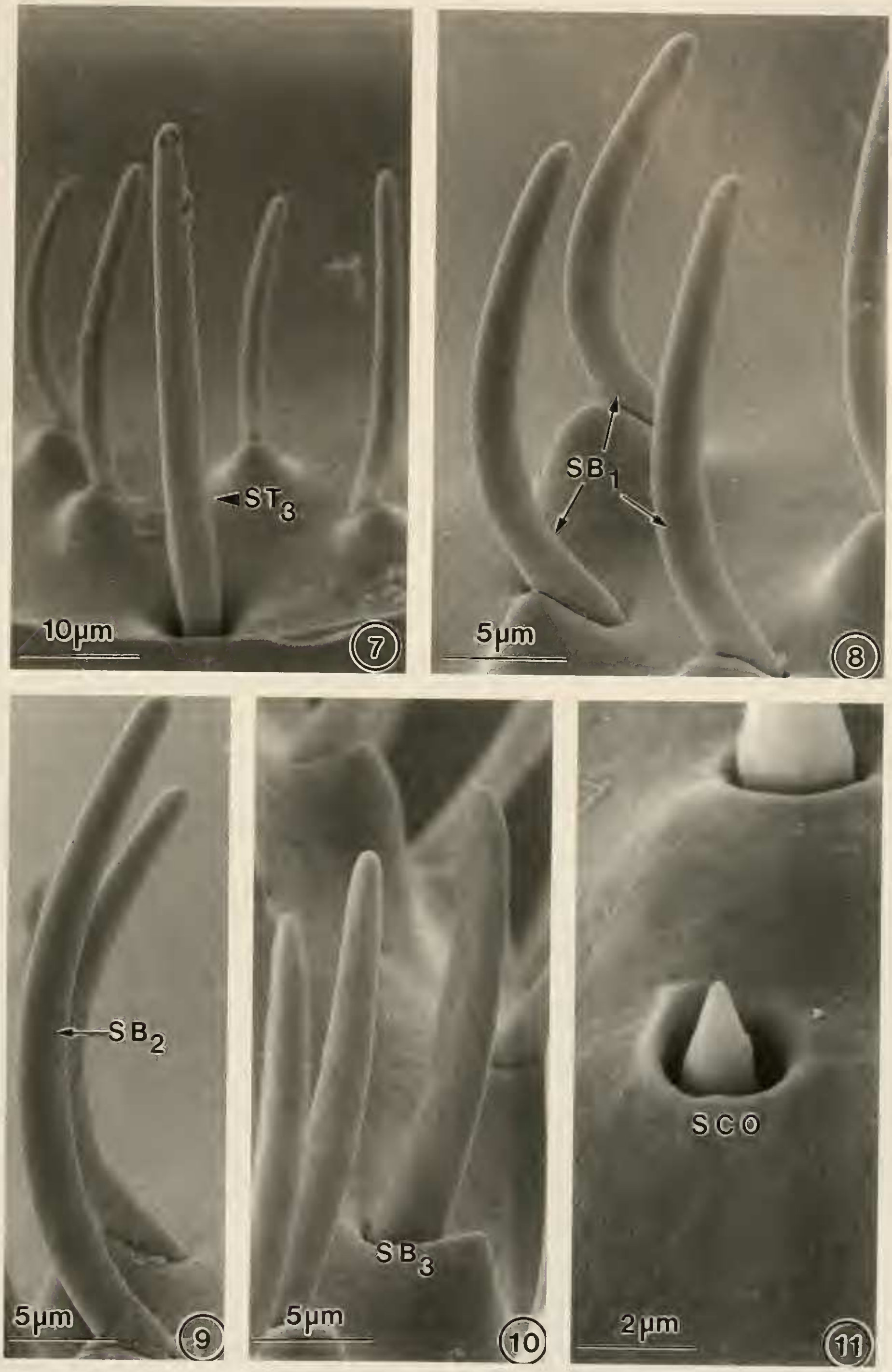
Sensillum ampullaceum (SA).—This type of sensillum is found only on the last flagellomere of male and female antennae. The opening of the sensillum is in the center of a slightly raised area that is delineated by an outer raised cuticular rim (Fig. 3) and is 1.4–1.7 μm in diameter. The peg portion can only be seen in specimens that were depigmented after the silver nitrate staining and it appears as a blackened, rod-shaped speck. Males and females have the same number of this sensillum, five or six.

Discussion

Two types of sensilla trichodea (ST_1 and ST_2) are probably mechanoreceptors. They have a well developed basal socket; they are not porous as indicated by the lack of staining, and every broken ST_1 and ST_2 sensillum, when viewed with the SEM, has a solid cuticular shaft. These above-mentioned characteristics are typical of certain types of mechanoreceptive sensilla. ST_1 and ST_2 resemble the trichoid sensilla type I on *Carabus fiduciarius saishutoicus* Csiki (Carabidae) (Kim and Yamasaki 1996), *Nebria brevicollis* (F.) (Carabidae) (Daly and Ryan 1979), *Tenebrio molitor* L. (Tenebrionidae) (Harbach and Larsen 1977) and the non-porous hairs of *Oryzaephilus surinamensis* L. (Silvanidae) (White and Luke 1986). These two sensilla (ST_1 and ST_2) make up a large proportion of the total number of antennal sensilla, and their position on the antenna also indicates that mechanoreception is an important function of the antenna. Mechanoreception would be an important sensory input as these beetles pushed their way through wood fibers in search of slime molds.

The blunt tip with an apical pore on ST_3 and the staining by the crystal violet and silver nitrate, which indicates porosity, are characteristics of a chemoreceptive sensillum. This sensillum on *Omoglymmius americanus* is similar to the type II sensillum trichodeum of *Nebria brevicollis* (Daly and Ryan 1979), *Carabus fiduciaruuis saishutoicus* (Kim and Yamasaki 1996) and the gently grooved sensillum in *Diabrotica virgifera* LeConte (Chrysomelidae) (Staetz et al. 1976). The ultrastructural data presented by Daly and Ryan (1979) clearly showed that this type of sensillum trichodeum is a contact chemoreceptor.

The three types of sensilla basiconica on



Figs. 7–11. Sensilla on the antenna of *Omoglymmius americanus*. 7, Short, stout, straight, blunt and grooved sensillum trichodeum type 3. 8, Short, slender, curved sensillum baciconicum type 1. 9, Long, slender, curved sensillum basiconicum type 2. 10, Stout, straight sensillum basiconicum type 3. 11, Peg and pit of the sensillum coeloconicum. Abbreviations: SB = sensillum basiconicum; SCO = sensillum coeloconicum; ST = sensillum trichodeum.

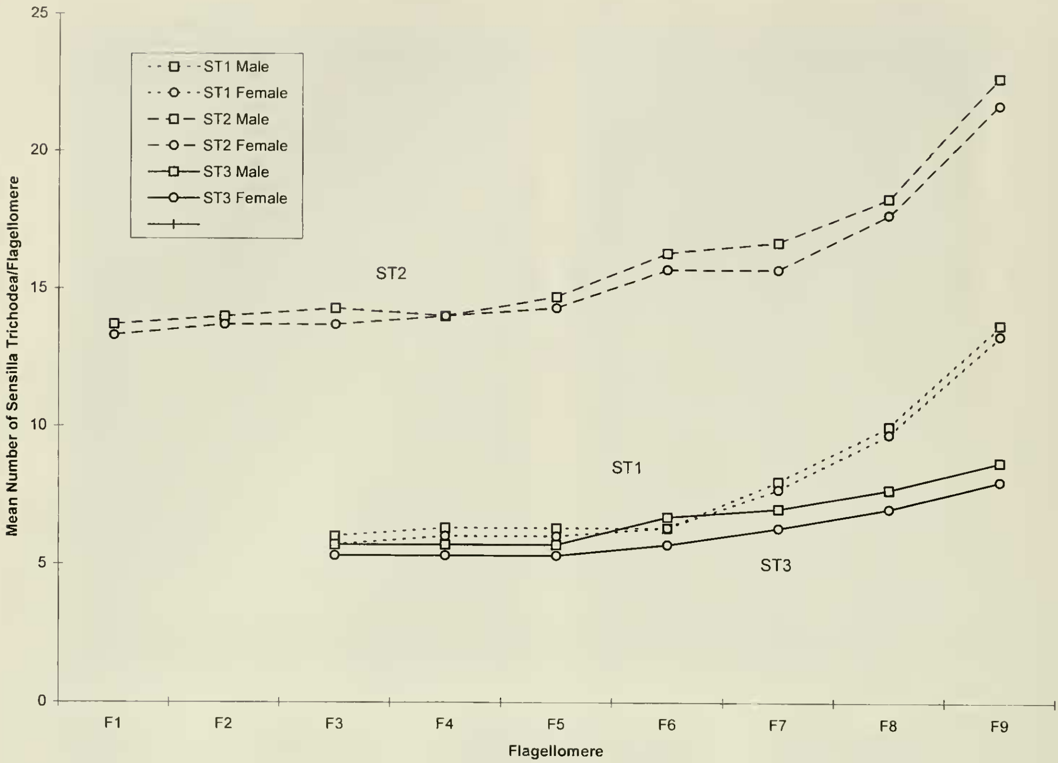


Fig. 12. Distribution of the three types of sensilla trichodea (ST) on the female and male antennae.

the male and female antennae are stained intensely by the silver nitrate and crystal violet, indicating a porous cuticle. At high magnification with the SEM many pores can be seen which cover the surface of these sensilla. SB_1 and SB_2 on *Omoglymius americanus* are morphologically similar to the basiconic sensilla found on the antenna of *Dendroctonus ponderosae* Hopkins (Scolytidae) (Whitehead 1981), *Oryzaephilus surinamensis* L. (White and Luke 1986), *Agriotes obscurus* L. (Elateridae) (Merivel et al. 1997), and *Carabus fiduciarius saishutoicus* Csiki (Kim and Yamasaki 1996) whereas the SB_3 of *O. americanus* resemble the type III found or the male and female antennae of *Psacothea hilaris* (Pascoe) (Cerambycidae) (Dai and Honda 1990), *C. fiduciarius saishutoicus* (Kim and Yamasaki 1996) and *Pterostichus* spp. (Carabidae) (Symondson and Williams 1997).

It is well documented that sensilla basiconica respond to various odors such as those from conspecifics and food sources. The sensillum coeloconicum and sensillum ampullaceum of *Omoglymmius americanus* are morphologically similar to those on the antennae of other beetles, especially carabids (Juberthie and Massoud 1977, Nagel 1979, Daly and Ryan 1979, Kim and Yamasaki 1996, Skilbeck and Anderson 1996, Symondson and Williams 1997). Both types are porous as indicated by the black deposit from the silver nitrate staining, so they are probably involved in some type of chemoreception like the sensilla basiconica ($SB_{1,2,3}$) and sensillum trichodeum, ST_3. The type of sensillum ampullaceum on *O. americanus,* which has an opening in the middle of a large, round, smooth plate-like area, is found only on several species of Carabidae (Nagel 1979, Kim and Yamasaki 1996, Symondson and Williams 1997).

Distribution patterns, numbers and types

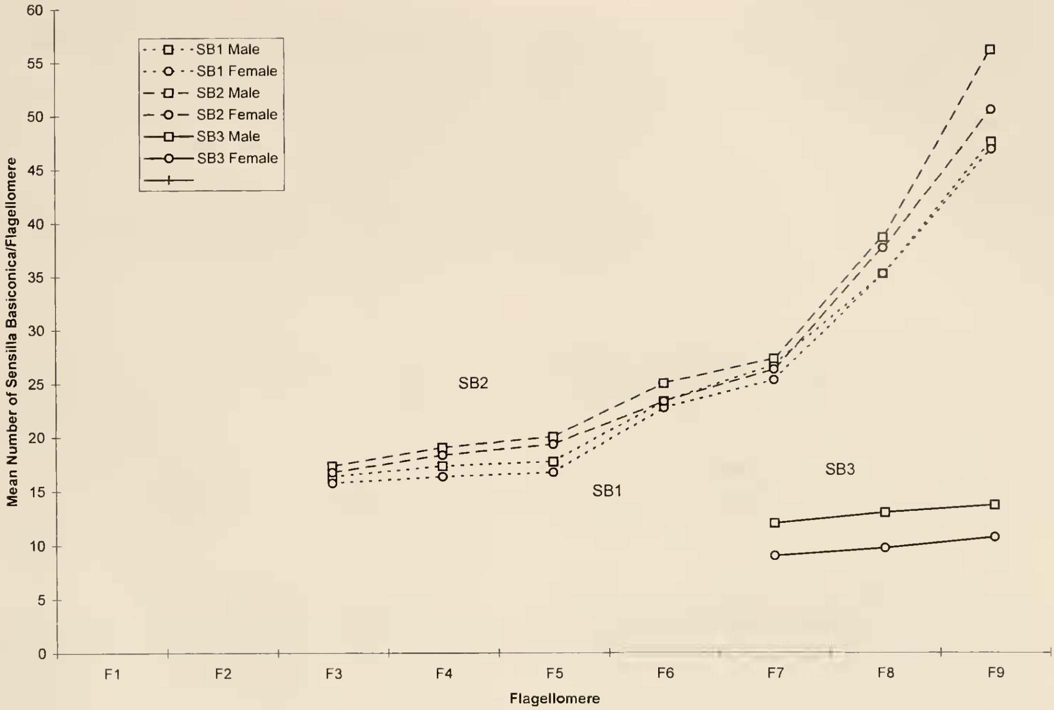


Fig. 13. Distribution of the three types of sensilla basiconica (SB) on the female and male antennae.

of sensilla on *Omoglymmius americanus* are similar to what is found on the antenna of carabid beetles (Daly and Ryan 1979, Nagel 1979, Kim and Yamasaki 1996, Symondson and Williams 1997). Sexual dimorphism exhibited between the females and males of *O. americanus* in the number of SB_3 and SCO is also found in other beetles such as *Psacothea hilaris* (Pascoe) (Dai and Honda 1990) and *Semiadalia undecimnotata* Schneider (Coccinellidae) (Jourdan et al. 1995). The sensilla on *Nebria brevicollis* cover the flagellar surface which differs from the distinct apical bands of sensilla in a recessed portion of flagellomeres 3 to 8 of *O. americanus*. This difference may be due to the different habitat and feeding strategies. *Nebria brevicollis* is an active predator in open spaces and has a more graceful antenna. *Omoglymmius americanus* is found in confined space pushing through solid wood. The antennal sensilla may need to be protected from mechanical damage, and the antenna itself is a tough ball and chain structure with a sharpened apical end, presumably also used for pushing through wood.

The clusters of microtrichia and pores on the flagellomeres of *Ommoglymmius americanus* also are situated on other body regions, especially around the antennal-cleaner located on the protibiae. These structures are also found in other Coleoptera (Faustini and Halsted 1982). They may be involved in secreting material that could be used in cleaning debris off the antennal surface, or they may secrete behavior ellicting chemicals (Martin 1975, Barbier et al. 1992).

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